TITLE

Deep Well Irrigation Pump

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority to U.S. Application Number 60/519,887, filed November 14, 2003, the entire disclosure of which is hereby incorporated by reference as if set forth at length herein.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

REFERENCE OF A "MICROFICHE APPENDIX"

Not applicable

FIELD OF THE INVENTION

The present invention relates generally to pumping devices.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention are now briefly described with reference to the following drawings:

FIG. 1 depicts one aspect of the present invention in accordance with the teachings presented herein.

FIG. 2 depicts a second aspect of the present invention in accordance with the teachings presented herein.

FIG. 3 depicts a third aspect of the present invention in accordance with the teachings presented herein.

FIG. 4 depicts a fourth aspect of the present invention in accordance with the teachings presented herein.

FIG. 5 depicts a fourth aspect of the present invention in accordance with the teachings presented herein,

FIG. 6 depicts a fourth aspect of the present invention in accordance with the teachings presented herein

DESCRIPTION OF THE INVENTION

The aspects, features and advantages of the present invention will become better understood with regard to the following description with reference to the accompanying drawings. What follows are preferred embodiments of the present invention. It should be apparent to those skilled in the art that the foregoing is illustrative only and not limiting, having been presented by way of example only. All the features disclosed in this description may be replaced by alternative features serving the same purpose, and equivalents or similar purpose, unless expressly stated otherwise. Therefore, numerous other embodiments of the modifications thereof are contemplated as falling within the scope of the present invention as defined herein and equivalents thereto.

FIG. 1 depicts an exemplary embodiment of an efficient pump apparatus 100 constructed in accordance with the present invention. As shown, the pump apparatus includes at a piston assembly loosely disposed within a cylinder. The piston assembly includes a driving cable connecting a top leaky piston and a bottom leaky piston having a check valve connected thereto.. The cylinder includes an outlet pipe on a upper portion thereof and a check valve located at a lower end of the cylinder. Key features of the pump apparatus 100 will now be described below.

Long Loose Leaky Piston

In an exemplary embodiment, the present invention employs two "long loose leaky pistons", having a length greater than that of conventional washers used in prior art rope and washer pumps. The "long loose leaky pistons", when reciprocated up and down in the cylinder, displace a volume of fluid and create a pressure head. The loose fit between the piston and the cylinder accommodates extremely loose dimensional tolerances (like those found in the inconsistent pipes that are available in many developing countries) and also has many other advantages listed below. Instead of having a tight fitting seal between the piston and cylinder they are both made of cylindrical pipes with the outer diameter of the piston being slightly smaller (up to a few % of the diameter) than the inner diameter of the cylinder. As the piston moves, the length of the piston creates a tortuous leak path making a hydrodynamic seal and allowing the piston to pressurize the fluid. The longer the piston, and the smaller the gap the more efficient this seal becomes.

The advantages of a "long-loose leaky piston" over other prior art pistons, include:

(1) There is very little friction between the piston and cylinder and this friction does not vary much with depth of pumping. The gap between the piston and cylinder is filled with fluid making them hydro-dynamically lubricated. In a normal piston and cylinder pump there is a piston cup (often leather or rubber) where the sealing force and thus the frictional force increases linearly with the depth of the pumping and greatly increases the pumping forces required. This new pump can thus be very energy efficient compared to a normal piston and cylinder pump.

(2) The hydrodynamic lubrication means that for clean fluids there is almost no problem with wear on either the piston or cylinder unlike for traditional piston pumps where wear is a major issue and requires the cylinder to be made of hardened material and the piston ring/cup to be replaced on a regular basis. (friction and wear are of-course closely related in this instance).

(3) Because there is no physical contact between the piston and cylinder the force required to lower the piston is also greatly reduced - it is now only the hydrodynamic drag thru the valve and this allows us to rely on gravity to lower the piston. In regular piston cylinder pumps piston rods are required to push the piston down (to overcome the frictional forces between the piston cup and the cylinder) on the return stroke.

(4) Because the leaky piston has a substantial leak path the pumping efficiency of the pump is highly velocity dependent (unlike for a traditional piston and cylinder pump). The faster the piston moves the more efficient the pump becomes. (And it also turns out that the longer the stroke the more efficient the pump becomes since less time is taken with the valves open between strokes and the water has to be re-accelerated fewer times - but this last point is also true on traditional piston pumps).

(5) Pumping efficiency is also dependent on the cylinder-piston gap and on the length of the piston (length of the leak path). A longer piston and tighter gap decreases the leakage and increases the volumetric efficiency but also increases the hydrodynamic drag so eventually in the limit it also decreases the energy efficiency. In a normal piston and cylinder pump the volumetric efficiency is

pretty much constant (because the tight seal between piston and cylinder) while the energy efficiency decreases with depth of pumping because of greatly increased frictional losses.

(6) A leaky piston is also much less dependent on precise dimensional tolerances between the piston and cylinder compared to a traditional piston pump, and also the surface quality of the cylinder (which usually has to be a very smooth machined surface) is no longer such a major issue. This means that a pump with a leaky piston can be made from fairly rough materials. However, dimensional straightness over the length of the piston and cylinder is still critical. This low need for exact tolerances means that it is possible for the pumping pipe to also act as the cylinder/cylinders, which is another big advantage of the design.

Flexible Cable Drive

In an exemplary embodiment, the present invention further employs a flexible cable drive (such as a chain, rope, wire, or some other flexible member). Most reciprocating deep well pumps use a rigid driving rod that can push the piston down (and pull it up). This design requires more material and bearing infrastructure to prevent the rod from buckling. The present invention uses gravity to return the bottom piston to its bottom position offering a cheaper, easier to assemble/transport, and reliable solution. There is no contact between the piston and the cylinder therefore no real drag occurs between the piston and the cylinder.

Top Piston and Bottom Piston

To enable a pressure head above ground, the present invention (which is very important for many applications including irrigation) includes a top leaky piston without

any additional valves (other than the two check valves in the bottom cylinder and piston). On the pressure stroke (forcing the top piston down), water is pressurized against the existing bottom check valve and out the outlet at the top of the well. This embodiment reduces the number of valves and seals.

It turns out, however, that the addition of another one-way outlet valve in the outlet pipe increases the efficiency of the pump. Without this extra valve the bottom loose piston gap sees the full (below ground and above ground) pressure head on the up stroke and it leaks a lot more and reduces efficiency. Another embodiment of the present invention employs an outside sleeve over the top cylinder with an outlet pipe only at the top end of it, instead of an outlet pipe at the bottom of the top cylinder. The addition of the outside sleeve feature keeps the overall diameter of the down hole components to a minimum allowing the pump to be used in a small diameter bore hole.

Additional Embodiments of the Present Invention

In accordance with an alternative embodiment of the present invention, a pump could be constructed with only the bottom leaky piston and a flexible tension member (rope, cable chain, etc) pulling it up and letting it drop by gravity. A pump can be built without the top leaky piston and without the outlet pipe.

In accordance with a second alternative embodiment of the present invention, any type of drive mechanism could be connected to the pump mechanism, including but not limited to other manual drives, a gasoline engine or electric motor.

In accordance with a third alternative embodiment of the present invention, a flexible piston option would work in the case where there is a non-straight cylinder. Here the hydrodynamic pressure would act to ensure that the piston flexes so that it won't get

jammed in the cylinder. This would be very useful for pumping fluids through curved pipes.

In accordance with a fourth alternative embodiment of the present invention, a double reciprocating piston pump (with two pistons one above the other operating 180 degrees out of synch) may be used, with two cables going down the pumping tube.

In accordance with a fifth alternative embodiment of the present invention, any type of valve could be used.

FIGS 2A-D depict details of the bottom leaky piston and FIGS 3A-B depict details of the top leaky piston.

FIGS. 4A-D depict aspects of alternative exemplary embodiments of pump apparatus 100.

FIGS. 5A-D depict of alternative exemplary embodiments of pump apparatus 100.

FIG. 6 depicts an assembly incorporating an exemplary embodiment of pump apparatus 100.

The present invention pump apparatus 100 is operated by repeatedly driving the top piston up and down while the bottom cylinder and check valve are submersed in a fluid. The fluid is pulled into the bottom check valve on the up stroke and is forced out of the outlet pipe under pressure during the down stroke. The two pistons are connected by a flexible tension member (rope, cable chain) that pulls up the bottom piston on the up stroke and then gravity returns the bottom piston to place on the down stroke. The pump 100 may be driven by two foot operated treadles like a small stair master machine.

The pump 100 adds a variable mechanical advantage on the drive mechanism giving a high mechanical advantage at the start of each stroke (allowing for increased

acceleration) and a low mechanical advantage at the end of each stroke (allowing for increased velocity) thereby maximizing the average piston velocity over the stroke and increasing the overall energy efficiency of the pump. This is an attractive feature for a human powered pump.

Having now described preferred embodiments of the invention, it should be apparent to those skilled in the art that the foregoing is illustrative only and not limiting, having been presented by way of example only. All the features disclosed in this specification (including any accompanying claims, abstract, and drawings) may be replaced by alternative features serving the same purpose, and equivalents or similar purpose, unless expressly stated otherwise. Therefore, numerous other embodiments of the modifications thereof are contemplated as falling within the scope of the present invention as defined by the appended claims and equivalents thereto.